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**VARIATIONS IN THE HUMAN SKELETON AND THEIR CAUSES.**

BY DANIEL G. BRINTON, M.D., LL.D., D.SC.\*

The purpose which I set before me in the present paper is to correct what I conceive to be a prevalent error in physical anthropology. In this science of late years we hear and read a great deal of "retrogressive anomalies," of "atavistic traits," of "pithecoïd," and "simian" and "lemurian reversions." Any unusual structural variation is at once claimed as the inexplicable apparition of some ancestral type, the ghost of some grandfather a thousand times removed, but ever inopportunately popping up in the present.

What I wish to show is that we have no right to assume that any such variation is a *reversion* until we are unable to show that it is a *result*. Whenever a present mechanical or physiological or pathological condition offers a sufficient cause for the variation, it is illogical to seek further. The more so, that all such words as "reversion" and "retrogression" take for granted hypotheses which have not yet been established beyond doubt. A variation, I maintain, is a *terminus ad quem*, a product of definite and present activities moving under fixed laws toward a calculable result. The terms "arrest of development" and "degeneration" offer no explanation because they refer to effects, not to causes. Variation is the rule, not the exception, in organic forms. Not its presence, but its absence, is the real problem of biology, and also of physical anthropology. Not that the white man has become white and the black man black, but that each remains so, is the true puzzle.†

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\* Read before the American Association for the Advancement of Science, in Brooklyn, August, 1894, Section of Anthropology.

† "The Discontinuity, of which Species is an expression, has its origin, not in the Environment nor in any phenomenon of Adaptation, but in the intrinsic nature of organisms themselves manifested in the original Discontinuity of Variation." Wm. Bateson, *Materials for the Study of Variation*, p. 567 (London, 1894).

Taking up one small, but typical branch of this large question, my purpose is to show that many of the traits of the skeleton usually called simian or pithecoïd, and explained by "reversion," are merely the results of mechanical or functional processes; further, that such traits are not racial in anything like the degree attributed to them, but are found in all races subjected to the influence of these processes, and that a primal difference of race based on such criteria is as unfounded an assumption as to infer, to quote a comparison of Virchow, that the African with his black skin and woolly hair must be descended from a black sheep or a poodle dog with these characteristics. When we find certain variations in the human skeleton bringing it closer to that of the gorilla, it does not in the least prove that man is descended from the gorilla, and that this is a case of reversion, but that in this instance he has been subjected to certain influences similar to those which have produced these traits in the gorilla. That is all.

With these preliminary sentences to show what I am aiming at, I proceed to my theme.

The composition of bone has always been the same. It has not appreciably varied since the earliest geologic time.† Roughly speaking, it contains one-third inorganic matter and two-thirds organic matter, though these proportions vary slightly in different bones and different animals, and considerably in certain diseases. The organic matter is called by the French anatomists *osseïn*, which is a convenient term. It is a common error, which I observe in some archeological works, to suppose that the older a bone is the less organic matter does it contain.\* So far is this from being the case that Dr. Buckland, the geologist, made a fairly rich soup of the bones of hyenas taken from the preglacial caves of southern England.‡ On the other hand, bones less than a century interred may have no *osseïn* whatever.

In studying variations it is very essential to understand thor-

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\* "La nature du tissu osseux n'a pas varié depuis les temps les plus reculés." Pouchut et Beauregard, *Traité d'Osteologie Comparée*, p. 29. (Paris, 1889.) Post-mortem changes, as the increase of fluorine or the substitution of inorganic materials, are, of course, not considered.

† As Dr. Joseph Jones, *Antiquities of Tennessee*, p. 71, when he assumes the proportion of organic matter as a test of antiquity.

‡ Quoted in Luther Holden, *Human Osteology*, p. 3.

oughly the growth of bone, the osteogenetic process. This acts radially from certain points called "centers of ossification." These are divided into primary and secondary. The former are few in number in each bone; but the latter may be indefinitely multiplied, giving rise to numerous anomalies. Secondary centers may, moreover, rise into activity long after the primaries have ceased, as in the case of synchondroses and sutures ossified in early life, which open later and new bone formation begins again.\* By them is also explained the occurrence of supernumerary bones, as the episternals, surplus ribs, vertebræ, etc. It has been rendered extremely probable by the researches of Dr. Dareste that many anomalies of this kind are produced by physical influences on the embryo, and some he has been able to bring about experimentally.

I have not the space, however, to enter into these interesting points further, and shall therefore proceed to call your attention to a few of the chief causes of variations which we find in the human skeleton. The first is—

### *Sexual Variation.*

From the remotest ages and in all races of men the skeleton of the female is somewhat smaller than that of the male. This is also true of nearly all other mammals and of birds. The bones are rather lighter and more delicately shaped in a woman, the clavicle is less curved and longer in proportion to the humerus, and the pubic rami meet at a more obtuse angle. The last mentioned is the only positive feminine distinction. Even this leading sexual criterion is obliterated in some branches of the human race, as, for example, among the Indo-Chinese, where the rami of the *os pubis* of the male meet at about the same angle as those of the female (Hervé). In spite of much that has been written about the fetal traits and undeveloped and semi-pithecoïd characteristics of the female skull and skeleton, I will challenge any anatomist to determine the sex when the pelvic bones are absent. Sexual variations are mainly explained by the laws which govern the process of reproduction in the two sexes, and need no other or more recondite hypothesis.

The second class which I shall name is

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\* See *Zeitschrift für Anthropologie*, 1887, p. 206.

*Lateral Variation.*

I have found little about this in the writers, either the anatomists or the anthropologists, though its prominence cannot be gainsaid. If you examine closely any skeleton you will find a number of small and often some very marked differences between the bones of the right and left sides. This is asymmetrical, lateral variation. The only field in which it has been carefully studied is cranial asymmetry, where the two lobes of the brain being different in size the skull has been molded irregularly on its two halves. This is not merely common, it is the rule, and the majority of human heads are thus asymmetrical, illustrating how potent are the factors of lateral variation.\*

Lateral variation depends upon dextral and sinistral preference, a phenomenon extending very widely over the animal kingdom down even to the snails, who have no hands, but who manifest it in the construction of their shells. No satisfactory explanation of it has yet been offered; but that the much larger use of the one side over the other would affect the bony structure is obvious. One important suggestion to anthropologists is here in place. In describing a homologous bone, it should always be added whether it is a right or a left, for this is often of weight in the argument. Perforation of the fossa olecrani of the humerus and the torsion of the humerus, for instance, vary considerably with the two sides of the body, as they also do with the sexes, being more frequent in the female, and on the left side, according to Broca, though some series, as those from the Salt River valley, do not support his view.

Both these causes of variation are, however, of minor importance compared with that from

*Mechanical Function.*

This may be either in the directions of increased or diminished function; and first of increased function.

It is well known to surgeons that hyperostosis arises from increased function. There is an interesting specimen in the Lon-

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\* "La plupart des crânes humaines sont asymétriques. L'asymétrie est manifeste dans la moitié des cas." F. C. Ribbe: *Etude sur l'Ordre d'Obliquation des Sutures du Crâne dans les Races humaines*, p. 159. (Paris, 1885.)

don College of Surgeons where the bones of the upper extremity are notably enlarged. They belonged to a paraplegic man, who for years used his arms for progression.\* In perfectly healthy subjects the circumference of the humerus in its upper third is sometimes one-third greater than in the lower, owing to the unusual development of the pectoralis major during life. Interesting examples of this from ancient Venezuelan skeletons are adduced by Dr. Marcano.†

Flattened or platycnemic tibias have often been mentioned as a pithecoïd reversion, and also as a racial trait. They are neither. Virchow has abundantly shown that they are produced in any race by the prolonged use of certain muscles, either in constant trotting, in prolonged squatting, in carrying burdens, or in the use of peculiar foot-gear. The proof that it is acquired is that it is never found in the tibias of young children.‡

To the same cause we must assign the increased or diminished torsion of the humerus, the anterior incurvation of the ulna below the sigmoid cavity, and the increased angle of retroversion of the head of the tibia; all of which have been catalogued as simian reversions. In Alikuluf skeletons from Tierra del Fuego, Martin found the latter angle increased from 7°, which it is in the European, to 20°, but very justly explains it by the habit of these islanders of crouching around their fires for hours every day.§ The pilastered femur has not been urged as a simian trait, but much has been made of it as a racial criterion. It is enough to say that the most extraordinary examples of it are those belonging to modern Indians obtained by Mr. Clarence Moore in Florida, and now in the Academy of Natural Sciences, at Philadelphia. The pilaster is nothing more than a proof of powerful femoral muscles, and has nothing to do with race.

The perforation of the olecranon fossa of the humerus, once claimed as allying the lower human races with the apes, and later as a racial criterion in the human species, has now been abandoned as either, and is regarded by unprejudiced anatomists, in

\* Samuel Wilks: *Pathological Anatomy*, p. 91.

† D. G. Marcano: *Ethnographie Précolombienne de Venezuela*, p. 43.

‡ See further the remarks of Dr. W. Matthews in his *Memoir on the Human Bones of the Hemenway Collection*, p. 224.

§ R. Martin: "Ein Beitrag zur Osteologie der Alikuluf," in *Vierteljahrsschrift der Naturforsch. Gesell. in Zurich*, 1892.

the words of Dr. Washington Matthews, as "the result of some mechanical cause connected with occupation."\*

An interesting effect of mechanical function has reference to cranial and facial form. There is a distinct correlation between prognathism, dolichocephaly, and early synostosis of the sagittal suture. The relation is not absolute because other factors enter into the problem, but it is quite recognizable. I take it that this arises from the greater development of the temporal muscles required in mastication by a prognathic jaw. These are attached to the temporal and parietal bones, and their action brings about a bilateral compression of the head, developing an opposed increased synostotic activity along the median line, followed, of course, by anterior and posterior pressure of the cerebral contents and consequent dolichocephaly.†

We find something quite analogous in the dog. He is not born with the median ridge of the skull common in other carnivora, and at birth the temporal muscles extend only partly up the side of the head, but by constant use of the jaws they rise further up, and the ridge is developed.

It is well known that the development of these muscles and its consequences have been claimed as simian traits. The most striking example is that of the New Caledonians. They are not a low race, yet it is precisely in skulls from that locality, now in the Museum of the University of Pennsylvania, that the late Dr. Joseph Leidy and I found the highest alveolar prognathism that either of us had ever seen, and the result in question, therefore, was a purely mechanical one and not at all a reversion.

Another consequence of complex mechanical action is the proportion which the face bears to the head. On his divisions of chamæprosopic, broad-faced, and leptoprosopic, narrow-faced, Professor Kollmann, of Basle, has founded his classification of human races; but in close families, such as the Veddahs of Ceylon, both are found, and we are forced to agree with Dr. R.

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\* *Memoir on the Human Bones of the Hemenway Collection*, p. 218.

† This is independent of the close relations which exist between prognathism and the position of the zygomatic arches and the occipital foramen. Here also we have an instance of present physical and mechanical action, leading to a simian analogy. Compare Hovelacque and Hervé, *Precis d'Anthropologie*, p. 69.

Martin that these are "termini of cranial variations only, proceeding in two directions, and not at all primitive types."\*

Passing now to diminished mechanical function and its results, I shall confine myself to a single example out of the very many which present themselves. The example I select is the teeth. The full development of the third molar in some prehistoric maxillaries and in the Australians has been pointed out as a survival. In fact, its late appearance and diminished vitality in what are called the higher races are purely mechanical results, their orthognathic jaws rendering it practically useless, so that today in artificial dentures it is omitted.

One effect of this diminished or diverted function is that its tubercles are usually reduced to three instead of being four or five; yet the presence of a tritubercular crown in certain other molars has been advanced by a distinguished American scientist as a sufficient proof of a "lemurian reversion" in human dentition—the more so, he argues, as it does not occur in the anthropoids. What appears to be a complete answer to this has been made by the able French anthropologist, Topinard, which he sums up in these words:

The contrast between the frequency of this apparent reversion in man and its absence in anthropoids proves merely that the two have not been subjected to the same tendencies, which can refer only to their respective methods of alimentation. This seeming retrogression in man is merely an adaptation of utility, and the inference which Professor Cope has drawn from it is, therefore, not legitimate.†

An even larger field of variation in the human skeleton is that offered by

#### *Deficient Nutrition.*

Perhaps this is seen most palpably in the variations of stature within the same race and people. Dr. Collignon, who has made such admirable anthropological studies of the population of France, finds the diminution of stature in certain districts explainable by one word, *la misère*, the lack of proper and sufficient alimentation.‡ Virchow, discussing the dwarfishness of the

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\* In *Archiv für Anthropologie*, 1893.

† Paul Topinard in *L'Anthropologie*, 1892, p. 707.

‡ Dr. R. Collignon, "Etude des Populations Françaises," in the *Association Française pour l'Avancement des Sciences*, 1892.



Lapps as compared with their cousins, the Finns, pronounces them *Kummerformen*, products of wretchedness. The shortest of the Bushmen are also the most miserable—those living amid the barren sands of the Kalahari desert. It is not argued that misery alone is the cause of inferior stature, but it is one of the causes, and a potent one.

Where we find it we find also other variations from the same cause. The sternum of a Bushman is often not as much developed as that of a new-born infant with us;\* true microcephaly is common in poorly nourished communities, as are spina bifida, rickets, and other diseases proceeding from osseous innutrition. There is nothing racial, still less pithecoïd, in any of these traits. They flow from obvious and present conditions.

This is also true of those small, intercalated bones which develop or persist in various sutures of the cranium and face, the epactal bone, the ossa Wormiana, and the recently observed *ossicula mentalia* of Mies.† The presence of these is to be understood as an evidence of deficient osteogenetic power, not its excess, as is sometimes stated. They are very generally associated with other signs of defective bone structure, as bifid sternum, perforation of the fossa olecrani, carious denture, and the like. They are most numerous in pathologic cases. Holden found over a hundred Wormian bones in the skull of a hydrocephalic infant,‡ and Hyrtl over three hundred in that of a cretin.§ They are formed from multiple secondary centers of ossification because the primary centers were too feeble to supply the needs of the system.

The epactal is really a large Wormian bone, and the attempt to assign it an ethnic value under the name of *os Incæ*, made

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\**Zeitschrift für Ethnologie*, 1890, p. 441. The effect of long-continued limited nutrition may bring about diminution of stature, symmetrical and without pathological traits. Thus the extinct elephants of Malta became toward the close of the life of the species quite small. A small but vigorous breed of horses is found where food is scarce. In the Canary Islands the oxen, the horses, and the men all become smaller on the smaller islands (de Varigny). This explains the origin of the dwarf races, the Negritos of the Spice islands, the Orang Pangang of the peninsula of Malacca, and the Pygmies of central Africa.

† See *L'Anthropologie*, 1893, No. iv.

‡ *Human Osteology*, p. 103.

§ *Lehrbuch der Anatomie*, p. 306.

by Von Tschudi, fails upon examination. It is found, with equal or greater frequency, among the ancient Arizonians of the Salt River valley, and Dr. Washington Matthews has inferred therefrom some closer relationship between these two peoples than that of race.\* But the simpler and more likely explanation is that in both instances we have a people subsisting upon a similar inadequate or at least non-osteoplastic alimentation, leading in each to similar semi-pathological variations from the norm.

This is well illustrated in the remarkable frequency of pathological exostoses in both peoples. Among the Saladoans they are found in about one-third of the subjects, a percentage nowhere equalled, so far as I know, except by the ancient skeletons from the vicinity of Lima, described by Virchow.†

It is a singular instance of the misinterpretation of ethnic anatomy when Professor Hervé, of the School of Anthropology of Paris, says that the presence of these Wormian bones and the complexity of the cranial sutures are a measure of the rapidity of brain development, and consequently a criterion of the position of a race in the scale of humanity. It is merely an indication of osteogenetic vigor, or the reverse.‡

Another interesting fact comes in in this connection. Virchow has convincingly demonstrated that anomalies of the bony structure in man are constantly and markedly greater among uncivilized than among civilized peoples, and consequently greater among ancient races than among those now living.§ This is in accordance with what holds good of the lower animals, for Bateson has shown by an extensive collation of evidence that Darwin was quite in error in maintaining that variation is greater in domesticated than in wild animals.|| In man its increase in

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\* See Dr. Matthews' article, "The Inca Bone," in the *American Anthropologist*, October, 1889; also his remarks on *Human Bones of the Hemenway Expedition* (Washington, 1893). The epactal or *os Incæ* arises from a secondary center of ossification which appears in the squamous portion of the occipital bone. Its genetic history is in all respects that of an *os Wormianum*.

† Ueber krankhaftveränderte Knochen alter Peruaner, in *Preuss. Akad. der Wissenschaften*, 1885.

‡ See Hovelacque and Hervé, *Precis d'Anthropologie*, p. 59.

§ See *Zeitschrift für Ethnologie*, 1891, pp. 54, 56, etc.

† Wm. Bateson, *Materials for the Study of Variation*, p. 572.

the savage state evidently depends upon fluctuations in the food-supply and frequent changes and excessive stress of mechanical function as the prime factors.

These brief suggestions will, I hope, be sufficient to place before you clearly another and, I believe, a juster method of studying the ethnic anatomy of the bones than you will find in ordinary treatises. The polygenists and the reversionists seem opposed to admitting the action of familiar natural causes. Because a human variation is pithecoïd they illogically jump to the conclusion that it is pitheco-genetic. Instead of looking on it as the natural result of an existing tendency, they claim it is a return to some primitive type. In fine, instead of accepting the nearest and plainest explanation of an observed fact, they put forward one in itself absolutely inexplicable and carrying with it a tissue of hypotheses, not one of which is more than a surmise.

#### DISCUSSION.

Professor Cope remarked that the paper of Dr. Brinton is interesting as bringing before the Section what is known or supposed to be true of the origin of certain peculiarities of the skeleton and dentition in some human races. Professor Cope insisted, however, that the demonstration of the mechanical origin of a given peculiarity by no means precludes that such peculiarity may not be an inheritance from or reversion to pithecoïd ancestors. It is the belief of many paleontologists that all of the form-characters of the vertebrate skeleton and, for that matter, of the hard parts of all animals, have been produced by muscular pressures and contractions, and the frictions, strains, and impacts due to these. The demonstrations by Virchow and others that such is the origin of the platycnemid tibia is directly in the line of evolutionary science, and shows us that atavistic and reversionary characters are found in the muscular system as well as in the skeleton; but the characters of the skeleton can generally be shown to be inherited, because they appear before birth and are found at some stage or another of fetal life.

The variations in the characters of the human skeleton are of very various significance and value, and the zoölogist and pale-

ontologist can perceive that they are sometimes misintrepreted by archeologists. Thus the presence of Wormian (Inca) bones and of a perforation of the olecranon fossa have no zoölogical value, while the prognathous jaws, tritubercular molar, and platycnemic tibia have such a value. The tufted hair of the negro has a human value only, as it does not occur in any of the quadrumana; but Dr. Brinton is not careful in his paper to point out these distinctions.

If the platycnemic tibia has been produced by muscular pressure in man it has been probably so produced in the apes, where it is a universal character. If the early fusion of the sagittal suture is produced by the vigorous contractions of the temporal muscle in the black races, due to prognathous jaws, this is probably why it is a universal character of the apes, where the jaws are still more prognathous. What may be the mechanical cause of prognathism is not explained by Dr. Brinton. That the prognathous jaws and platycnemic tibia are not found in the fetus by no means proves that they are not inherited characters. Besides the fact, already mentioned, that we are only thrown back on an inherited muscular structure, it is further to be marked that characters which indicate the evanescence or degeneracy of parts do not usually appear in the fetus, but are disclosed at later stages. Prognathous jaws are disappearing from the higher races, and the process of disappearance is in this point accomplished by a retention of the fetal face, which is excessively orthognathous. Prognathism is characteristic of most of the lower mammalia, and whenever man displays it, if he be, as evolutionists believe, descended from some other mammal, he is simply continuing to develop the old character in the old manner. The same reasoning applies to the platycnemic tibia and the tritubercular molar.

As regards the lemurine character of the tritubercular molar (which is formed before it is erupted from the alveolus), the term is a good one, as indicating the nearest of kin to man which present such molars; but this type can with equal propriety be called, as I have shown, the primitive placental molar. The lemur is the highest form next to man which displays it, but it was universal among placentals at one geologic epoch. It is possible that Topinard's suggestion as to the cause of its appearance in man is the correct one, as I made the same many years before; but that does not affect its value as an evidence of

reversion, as in the cases already cited. There are various other ways in which molar teeth may degenerate besides reversion to trituberculy, with which dentists are familiar, and which may be explained as Topinard and I have done, *i. e.*, by change of food; but why the regular and normal mode should be trituberculy and not one of these other modes requires additional explanation. This explanation is that in a regular or normal retrogressive modification of structure is likely to return on the line by which it advanced; this is atavism or reversion.

That the Anthropoids have been directly derived by descent from the Lemuridæ rather than from the Old World monkeys (Cercopithecidæ) is probable for various reasons. I only mention now that this view is confirmed by the recent discovery by Forsyth Major, in Madagascar, in beds of Pleistocene age, of a skull of a new genus of Lemuridæ with tritubercular molars whose single species is nearly as large as a chimpanzee.

In closing these remarks I call attention to the frequent muscular and occasional cerebral anomalies found in the negro, which are of simian character and which indicate simian descent. An excellent synopsis of these has been given by Dr. Frank Baker in his address at Cleveland, as Vice-President of this Section, and by Prof. H. F. Osborn in lectures before the New York College of Physicians.

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